the present century, made about thirty-six ascents of the peak, for the purpose of making barometric observations.

In 1854 a society at Bagnères founded on the Col de Sencours, 511 feet below the Pic, on a hill immediately above the Lake Oncet, a hotel for tourists. It is this hotel which the Ramond Society has used as a temporary observatory, until the Government provide the means of erecting a proper building on the summit of the Pic. On August 1, 1873, the Commission appointed by the Society provided a tolerably complete set of meteorological apparatus on the Col de Sencours. Regular observations were carried on till October 10, when want of funds cut them short. On June 1 of the following year an observer, along with the President of the Commission, General de Nansouty, installed themselves and remained till December 25, when, as we recorded at the time, the severity of the winter, for which they were insufficiently provided, compelled them to beat a precipitate retreat. On June 1 last year, General de Nansouty and M. Baylac again established themselves in the temporary observatory, and it is to be hoped they will be able to remain throughout the whole of the winter. An avalanche did considerable damage to the meteorological hut, and injured several of the instruments; fortunately, however, the observers managed to repair most of the damage done. The instruments which have been provided are of the best kind, and already observations of great value have been made, some of which have been published by the Ramond Society.

This Society determined to accomplish the erection of a proper observatory on the Pic du Midi itself, and has appealed to every quarter from which funds are likely to be obtained. The work of construction has already been begun. The building will be composed of three parts. The dwelling-house, situated seven metres below the summit, is in part subterranean, and will open only on the south side. It communicates by a tunnel with a circular vaulted erection, which will contain the barometer, the magnetic apparatus, &c. At a little distance will be solidly built the Montsouris hut, intended to cover the instruments which must be subjected to the direct influence of the atmosphere.

The work is thus in progress, and there is every reason to believe that it will soon be successfully completed, and the station become one of the most important physical observatories, not only in France, but on the globe.

PROF. TYNDALL ON GERMS[*]

THE author refers in an introduction to an inquiry on the decomposition of vapours and the formation of actinic clouds by light, whereby he was led to experiment on the floating matter of the air. He refers to the experiments of Schwann, Schröder and Dusch, Schröder himself, to those of the illustrious French chemist Pasteur, to the reasoning of Lister and its experimental verification, regarding the filtering power of the lungs; from all of which he concluded, six years ago, that the power of developing life by the air, and its power of scattering light, would be found to go hand in hand. He thought the simple expedient of examining by means of a beam of light, while the eye was kept sensitive by darkness, the character of the medium in which their experiments were conducted, could not fail to be useful to workers in this field. But the method has not been much turned to account, and this year he thought it worth while to devote some time to the more complete demonstration of its utility.

He also wished to free his mind, and if possible the minds of others, from the uncertainty and confusion which now beset the doctrine of "spontaneous generation." Pasteur has pronounced it "a chimera," and expressed the undoubting conviction that this being so it is possible to remove parasitic diseases from the earth. To the medical profession, therefore, and through them to humanity at large, this question is one of the last importance. But the state of medical opinion regarding it is not satisfactory. In a recent number of the *British Medical Journal*, and in answer to the question, "In what way is contagium generated and communicated?" Messrs. Braidwood and Vacher reply that notwithstanding "an almost incalculable amount of patient labour, the actual results obtained, especially as regards the manner of generation of contagium, have been most disappointing. Observers are even yet at variance whether these minute particles, whose discovery we have just noticed, and other disease germs, are always produced from like bodies previously existing, or whether they do not, under certain favourable conditions, spring into existence *de novo*."

With a view to the possible diminution of the uncertainty thus described, the author submits without further preface to the Royal Society, and especially to those who study the etiology of disease, a description of the mode of procedure followed in this inquiry, and the results to which it has led.

A number of chambers, or cases, were constructed, each with a glass front, its top, bottom, back and sides being of wood. At the back is a little door which opens and closes on hinges, while into the sides are inserted two panes of glass, facing each other. The top is perforated in the middle by a hole 2 inches in diameter, closed air-tight by a sheet of india-rubber. This sheet is pierced in the middle by a pin, and through the pin-hole is passed the shank of a long pipette ending above in a small funnel. A circular tin collar 2 inches in diameter and 1½ inch high, surrounds the pipette, the space between both being packed with cotton-wool moistened by glycerine. Thus the pipette, in moving up and down, is not only firmly clasped by the india-rubber, but it also passes through a stuffing box of sticky cotton-wool. The width of the aperture closed by the india-rubber secures the free lateral play of the lower end of the pipette. Into two other smaller apertures in the top of the case are inserted, air-tight, the open ends of two narrow tubes, intended to connect the interior space with the atmosphere. The tubes are bent several times up and down, so as to intercept and retain the particles carried by such feeble currents as changes of temperature might cause to set in between the outer and the inner air.

The bottom of the box is pierced with two rows, sometimes with a single row of apertures, in which are fixed air-tight, large test-tubes, intended to contain the liquid to be exposed to the action of the moteless air.

On Sept. 10 the first case of this kind was closed. The passage of a concentrated beam across it through its two side windows then showed the air within it to be laden with floating matter. On the 13th it was again examined. Before the beam entered, and after it quitted the case, its track was vivid in the air, but within the case it vanished. Three days of quiet sufficed to cause all the floating matter to be deposited on the sides and bottom, where it was retained by a coating of glycerine, with which the interior surface of the case had been purposely varnished. The test-tubes were then filled through the pipette, boiled for five minutes in a bath of brine or oil, and abandoned to the action of the moteless air. During ebullition aqueous vapour rose from the liquid into the chamber, where it was for the most part condensed, the uncondensed portion escaping, at a low temperature, through the bent tubes at the top. Before the brine was removed little stoppers of cotton-wool were inserted in the bent tubes, lest the entrance of the air into the cooling chamber should at first be forcible enough to carry motes along with it. As soon, however, as the ambient temperature was assumed by the air within the case, the cotton-wool stoppers were removed.

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[*] On the Optical Deportment of the Atmosphere in reference to the Phenomena of Putrefaction and Infection. Abstract of a paper read before the Royal Society, January 13th, by Prof. Tyndall, F.R.S. (Communicated by the author.)

We have here the oxygen, nitrogen, carbonic acid, ammonia, aqueous vapour, and all the other gaseous matters which mingle more or less with the air of a great city. We have them, moreover, "untortured" by calcination and unchanged even by filtration or manipulation of any kind. The question now before us is, can air thus retaining all its gaseous mixtures, but self-cleansed from mechanically suspended matter, produce putrefaction? To this question both the animal and vegetable worlds return a decided negative.

Among vegetables experiments have been made with hay, turnips, tea, coffee, hops, repeated in various ways with both acid and alkaline infusions. Among animal substances are to be mentioned many experiments with urine; while beef, mutton, hare, rabbit, kidney, liver, fowl, pheasant, grouse, haddock, sole, salmon, cod, turbot, mullet, herring, whiting, eel, oyster have been all subjected to experiment.

The result is that infusions of these substances exposed to the common air of the Royal Institution laboratory, maintained at a temperature of from 60° to 70° Fahr., all fell into putrefaction in the course of from two to four days. No matter where the infusions were placed, they were infallibly smitten. The number of the tubes containing the infusions was multiplied till it reached six hundred, but not one of them escaped infection.

In no single instance, on the other hand, did the air, which had been proved moteless by the searching beam, show itself to possess the least power of producing Bacterial life or the associated phenomena of putrefaction. The power of developing such life in atmospheric air, and the power of scattering light, are thus proved to be indissolubly united.

The sole condition necessary to cause these long-dormant infusions to swarm with active life is the access of the floating matter of the air. After having remained for four months as pellucid as distilled water, the opening of the back-door of the protecting case, and the consequent admission of the mote-laden air, suffice in three days to render the infusions putrid and full of life.

That such life arises from mechanically suspended particles is thus reduced to ocular demonstration. Let us inquire a little more closely into the character of the particles which produce the life. Pour Eau de Cologne into water, a white precipitate renders the liquid milky. Or, imitating Brücke, dissolve clean gum mastic in alcohol, and drop it into water, the mastic is precipitated, and milkiness produced. If the solution be very strong the mastic separates in curds; but by gradually diluting the alcoholic solution we finally reach a point where the milkiness disappears, the liquid assuming, by reflected light, a bright cerulean hue. It is, in point of fact, the colour of the sky, and is due to a similar cause, namely, the scattering of light by particles, small in comparison to the size of the waves of light.

When this liquid is examined by the highest microscopic power it seems as uniform as distilled water. The mastic particles, though innumerable, entirely elude the microscope. At right angles to a luminous beam passing among the particles they discharge perfectly polarised light. The optical deportment of the floating matter of the air proves it to be composed, in part, of particles of this excessively minute character. When the track of a parallel beam in dusty air is looked at horizontally through a Nicol's prism, in a direction perpendicular to the beam, the longer diagonal of the prism being vertical, a considerable portion of the light from the finer matter is extinguished. The coarser motes, on the other hand, flash out with greater force, because of the increased darkness of the space around them. It is among the finest ultra-microscopic particles that the author shows the matter potential as regards the development of Bacterial life is to be sought.

But though they are beyond the reach of the microscope, the existence of these particles, foreign to the atmosphere but floating in it, is as certain as if they could be felt between the fingers, or seen by the naked eye. Supposing them to augment in magnitude until they come, not only within range of the microscope, but within range of the unaided senses. Let it be assumed that our knowledge of them under these circumstances remains as defective as it is now—that we do not know whether they are germs, particles of dead organic dust, or particles of mineral matter. Suppose a vessel (say a flower-pot) to be at hand filled with nutritious earth, with which we mix our unknown particles; and that in forty-eight hours subsequently buds and blades of well-defined cresses and grasses appear above the soil. Suppose the experiment when repeated over and over again to yield the same unvarying result. What would be our conclusion? Should we regard those living plants as the products of dead dust or mineral particles; or should we regard them as the offspring of living seeds? The reply is unavoidable. We should undoubtedly consider the experiment with the flower-pot as clearing up our pre-existing ignorance; we should regard the fact of their producing cresses and grasses as proof positive that the particles sown in the earth of the pot were the seeds of the plants which have grown from them. It would be simply monstrous to conclude that they had been "spontaneously generated."

This reasoning applies word for word to the development of *Bacteria* from that floating matter which the electric beam reveals in the air, and in the absence of which no Bacterial life has been generated. There seems no flaw in this reasoning; and it is so simple as to render it unlikely that the notion of Bacterial life developed from dead dust can ever gain currency among the members of a great scientific profession.

A novel mode of experiment has been here pursued, and it may be urged that the conditions laid down by other investigators in this field, which have led to different results, have not been strictly attended to. To secure accuracy in relation to these alleged results, the latest words of a writer on this question, who has influenced medical thought both in this country and in America, are quoted. "We know," he says, "that boiled turnip or hay-infusions exposed to ordinary air, exposed to filtered air, to calcined air, or shut off altogether from contact with air, are more or less prone to swarm with *Bacteria* and vibriones in the course of from two to six days." Who the "we" are who possess this knowledge is not stated. The author is certainly not among the number, though he has sought anxiously for knowledge of the kind. He thus tests the statements in succession.

And first, with regard to the filtered air. A group of twelve large test-tubes were caused to pass air-tight through a slab of wood. The wood was coated with cement, in which, while hot, a heated "propagating glass" resembling a large bell-jar was imbedded. The air within the jar was pumped out several times, air filtered through a plug of cotton-wool being permitted to supply its place. The test-tubes contained infusions of hay, turnip, beef, and mutton—three of each—twelve in all. They are as clear and cloudless at the present moment as they were upon the day of their introduction; while twelve similar tubes, prepared at the same time in precisely the same way and exposed to the ordinary air, are clogged with mycelium, mould, and *Bacteria*.

With regard to the calcined air, a similar propagating glass was caused to cover twelve other tubes filled with the same infusions. The "glass" was exhausted and carefully filled with air which had passed through a red-hot platinum tube, containing a roll of red-hot platinum gauze. Tested by the searching beam, the calcined air was found quite free from floating matter. Not a speck has invaded the limpidity of the infusions exposed to it, while twelve similar tubes placed outside have fallen into rottenness.

The experiments with calcined air took another form. Six years ago it was found that to render the laboratory air free from floating matter, it was only necessary to permit a platinum wire heated to whiteness to act upon it for a sufficient time. Shades, containing pear juice, damson juice, hay- and turnip-juice, and water of yeast, were freed from their floating matter in this way. The infusions were subsequently boiled and permitted to remain in contact with the calcined air. They are quite unchanged to the present hour, while the same infusions exposed to common air became mouldy and rotten along ago.

It has been affirmed that turnip- and hay-infusions rendered slightly alkaline are particularly prone to exhibit the phenomena of spontaneous generation. This was not found to be the case in the present investigation. Many such infusions have been prepared, and they have continued for months without sensible alteration.

Finally, with regard to infusions wholly withdrawn from air, a group of test-tubes, containing different infusions, was boiled under a bell-jar filled with filtered air, and from which the air was subsequently removed as far as possible by a good air-pump. They are now as pellucid as they were at the time of their preparation, more than two months ago, while a group of corresponding tubes exposed to the laboratory air have all fallen into rottenness.

There is still another form of experiment on which great weight has been laid—that of hermetically sealed tubes. On April 6 last, a discussion on the "Germ Theory of Disease" was opened before the Pathological Society of London. The meeting was attended by many distinguished medical men, some of whom were profoundly influenced by the arguments, and none of whom disputed the facts brought forward against the theory on that occasion. The following important summary of these was then given:—"With the view of settling these questions, therefore, we may carefully prepare an infusion from some animal tissue, be it muscle, kidney, or liver; we may place it in a flask whose neck is drawn out and narrowed in the blowpipe-flame, we may boil the fluid, seal the vessel during ebullition, and keeping it in a warm place, may await the result, as I have often done. After a variable time the previously heated fluid within the hermetically sealed flask swarms more or less plentifully with *Bacteria* and allied organisms."

Previous to reading this statement the author had operated upon tubes of hay- and turnip-infusions, and upon 21 tubes of beef, mackerel, eel, oyster, oatmeal, malt, and potato, hermetically sealed while boiling, not by the blowpipe, but by the far more handy spirit-lamp flame. In no case was any appearance whatever of *Bacteria* or allied organisms observed. The perusal of the discussion just referred to caused the author to turn again to muscle, liver, and kidney, with a view of varying and multiplying the evidence. Fowl, pheasant, snipe, partridge, plover, wild duck, beef, mutton, heart, tongue, lungs, brains, sweetbread, tripe, the crystalline lens, and vitreous humour of an ox, herring, haddock, mullet, codfish, sole, were all embraced in the experiments. There was neither mistake nor ambiguity about the result. One hundred and thirty-nine of the flasks operated on were exhibited, and not one of this cloud of witnesses offers the least countenance to the assertion that liquids within flasks, boiled and hermetically sealed, swarm, subsequently, more or less plentifully with *Bacteria* and allied organisms.

The evidence furnished by this mass of experiments, that errors either of preparation or observation have been committed, is, it is submitted, very strong. But to err is human; and in an inquiry so difficult and fraught with such momentous issues, it is not error, but the persistence in error by any of us, for dialectic ends, that is to be deprecated. The author shows by illustrations the risks of error run by himself. On Oct. 21 he opened the back-door of a case containing six test-tubes filled with an infusion of turnip which had remained perfectly clear for three weeks, while three days sufficed to crowd six similar tubes exposed to mote-laden air with *Bacteria*. With a small pipette he took specimens from the pellucid tubes, and placed them under the microscope. One of them yielded a field of Bacterial life, monstrous in its copiousness. For a long time he tried vainly to detect any source of error, and was perfectly prepared to abandon the unvarying inference from all the other experiments, and to accept the result as a clear exception to what had previously appeared to be a general law. The cause of his perplexity was finally traced to the tiniest speck of an infusion containing *Bacteria*, which had clung by capillary attraction to the point of one of his pipettes.

Again, three tubes containing infusions of turnip, hay, and mutton, were boiled on Nov. 2 under a bell-jar containing air so carefully filtered that the most searching examination by a concentrated beam failed to reveal a particle of floating matter. At the present time every one of the tubes is thick with mycelium and covered with mould. Here surely we have a case of spontaneous generation. Let us look to its history.

After the air has been expelled from a boiling liquid it is difficult to continue the ebullition without "bumping." The liquid remains still for intervals, and then rises with sudden energy. It did so in the case now under consideration, and one of the tubes boiled over, the liquid over-spreading the resinous surface in which the bell-jar was imbedded, and on which, doubtless, germs had fallen. For three weeks the infusions had remained perfectly clear. At the end of this time, with a view of renewing the air of the jar, it was exhausted, and refilled by fresh air which had passed through a plug of cotton-wool. As the air entered, attention was attracted by two small spots of penicillium resting on the liquid which had boiled over. It was at once remarked that the experiment was a dangerous one, as the entering air would probably detach some of the spores of the penicillium and diffuse them in the bell-jar. This was, therefore, filled very slowly, so as to render the disturbance a minimum. Next day, however, a tuft of mycelium was observed at the bottom of one of the three tubes, namely that containing the hay-infusion. It has by this time grown so as to fill a large portion of the tube. For nearly a month longer the two tubes containing the turnip- and mutton-infusions maintained their transparency unimpaired. Late in December the mutton-infusion, which was in dangerous proximity to the outer mould, showed a tuft upon its surface. The beef-infusion continued bright and clear for nearly a fortnight longer. The recent cold weather caused me to add a third gas-stove to the two which had previously warmed the room in which the experiments are conducted. The warmth of this stove played upon one side of the bell-jar; and on the day after the lighting of the stove, the beef-infusion gave birth to a tuft of mycelium. In this case the small spots of penicillium might have readily escaped attention; and had they done so we should have had three cases of "spontaneous generation" far more striking than many that have been adduced.

(*To be continued.*)

NOTES

M. E. Quetelet has issued a Notice giving a brief account of the recent progress of the Brussels Observatory, which has been established only in the face of great difficulties. In 1833 meteorological observations were commenced to be made, and a few years after astronomical observations were added by the elder Quetelet. The work which is at present being carried on has for its object a general revision of the variable stars. Seventy